SECTION 2

QUALITY ASSURANCE AND QUALITY CONTROL

2.1 Introduction

2.1.1 Fish studies, like macroinvertebrate studies (USEPA, 1990a), require a strong quality assurance (QA) program and effective quality control (QC) procedures that encompass field and laboratory data collection activities. The term "quality assurance" refers to an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence. The term "quality control" refers to the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users. The aim is to provide quality that is satisfactory, adequate, dependable, and economical (modified from USEPA, 1974; 1978).

2.1.2 Quality assurance programs have two primary functions in a biomonitoring/bioassessment laboratory. First, the project or program should define the data quality needed for the program's goals in terms of accuracy, precision, representativeness, comparability, and completeness (see Subsection 2.6, Fish Collection). The second function is to provide information on the success with which the measurement data meet these goals.

2.1.3 Quality assurance and quality control (QA/QC) must be a continuous process in the biomonitoring/bioassessment program that includes all aspects of the program, including field collection and preservation, habitat assessment, sample processing, data analysis, and reporting. Otherwise, the data generated may not be reliable and useful for decision making, and the results will be of little use in assessing and establishing the conditions (health, biological integrity, and quality of the water resources) of the water body under study. Without an appropriate program of quality assurance and quality control, data will be of unknown quality, limiting its interpretation and usefulness. Quality must be assured before the results can be accepted with any scientific studies. As described below, quality assurance is accomplished through establishment of thorough investigator training, protocols, guidelines, comprehensive field and laboratory data documentation and management, verification of data reproducibility, and instrument calibration.

2.1.4 To support the operation of a consistent plan, the persons responsible for QA should consult the EPA Quality Assurance manual (USEPA, 1984a; 1984b; 1989; 1992b). All EPA QA programs are implemented and operated under the authority of EPA Order 5360.1. USEPA (1984b) serves as guidance and describes the policy, objectives, and responsibilities of all USEPA programs, regional offices, and laboratories producing data for USEPA to institute a specific QA program. Each office or laboratory that generates data under USEPA's QA/QC program must implement, at a minimum, the prescribed procedures to ensure that precision, accuracy, completeness, comparability, and representativeness of data are known and documented.

2.1.4.1 Information and discussion of statistical tools, data quality objectives, comparison of good laboratory and field practices, and other quality assurance considerations in the context of ecological research are found in USEPA (1992b). Each agency should have a designated QA/QC officer (or a person in charge of the program) responsible for reviewing project plans, SOPs, etc. and auditing the program for improving performance, etc.

2.1.5 The Fish Bioassessment Protocols for Use In Streams and Rivers, Section 8, can be modified to achieve various data quality objectives. A different habitat assessment approach, replicate sampling, more intensive sample enumeration, or modified analytical metrics may be preferred by a particular State over the approaches in this Section. Such refinements can be accommodated, provided they are clearly documented in an USEPA approved QA program and/or project plan.

2.1.6 Components of the QA program (Khalil and Tuckfield, 1992; USEPA, 1984a; 1984b; 1990a; 1991a; 1992a; 1992b) should include the following:

2.1.6.1 Approved methodology and documentation for the collection, preservation, and analysis of data.

2.1.6.2 Documentation and manufacturer's instructions for sampling equipment, flow measuring devices, and other measuring instruments such as pH, DO, and conductivity meters.

2.1.6.3 Methods and documentation to assure that representative samples are collected (See Subsection 2.2, Data Quality Objectives and Subsection 2.8, Standard Operating Procedures).

2.1.6.4 Methods and documentation to assure the precision of sampling and analysis procedures. Collecting precise fish data usually requires extensive sampling as well as careful design.

2.1.6.5 Methods to assure accurate and timely recording, storage, and retrieval of data.

2.1.6.6 Documentation to assure sample evaluation, statistical evaluation, and performance evaluation of laboratory procedures.

2.2 Data Quality Objectives

2.2.1 A full assessment of the data quality needed to meet the study objectives should be made prior to preparation and implementation of the QA plan. Data quality is a measure or description of the completeness, type, and amount of error associated with a data set. Determination of data quality is accomplished through the development of data quality objectives (DQOs), which are statements of the level of uncertainty a decision-maker is willing to accept or the quality of the data needed to support a specific environmental decision or action and the rationale behind those statements and levels of data quality. Both qualitative and quantitative descriptors of data quality must be considered to determine whether data are appropriate or adequate for a particular application. However, DQOs are target values and not necessarily

criteria for the acceptance or rejection of data (Table 1). Table 1 is a summary listing QA objectives for precision and completeness. Data quality requirements should be based on prior knowledge of the sampling procedures or measurements system by use of replicate (duplicate) analyses, reference conditions (site-specific or ecoregional), or requirements of the specific project (USEPA, 1989).

2.2.2 Data quality objectives are developed in three stages. During the first stage, the decision-maker determines what information is needed, reasons for the need, how the information will be used, and specifies time and resource constraints. The second stage involves the technical staff and the decision-maker interacting to establish a detailed and clarified specification of the problem, how the information will be used, any constraints imposed on the data collection, and what limitations of the information will be acceptable. The third stage involves the examination of the possible approaches to collection and analysis of the data and a determination of the quality of the data that can be expected to result from each approach. The best approach is selected based upon the criteria agreed upon in the second stage. It may be necessary to modify the objectives of the study during the development of the DQOs. Details for developing DQOs are described in USEPA (1986; 1989). These documents are available from the Quality Assurance Management Staff, Office of Research and Development, Washington, DC 20460 and the Center For Environment Research Information (CERI), U.S. Environmental Protection Agency, Cincinnati, OH 45268. The CERI information and document ordering phone number is (513) 569-7562. Johnson and Nielsen (1983), Ohio EPA (1989), and Simon (1991) discuss sampling considerations for collecting fish data.

2.2.3 After the DQOs are established, the detailed project QA plan should be finalized stating specific quantitative and qualitative data quality goals and QC procedures that will be used to control and characterize error (USEPA, 1980; 1989; 1992b). These goals, based on the DQOs, will be the criteria for measuring the success of the QA program.

2.2.4 The Quality Assurance Management Staff, Office of Modeling, Monitoring Systems, and Quality Assurance, is responsible for providing general guidance for the inclusion of DQOs in quality assurance program and project plans, and for providing guidance to the regions on the application of the DQOs development process. The EPA regional offices are responsible for ensuring that state QA programs and project plans are in conformance with grant requirements specified in 40 CFR Part 30, and for assisting the states in developing DQOs requirements and Quality Assurance Program Plans (QAPP) that meet state needs (USEPA, 1989).

2.2.5 Regional and state laboratories or monitoring personnel in need of specific guidance in preparing Quality Assurance Project Plans or development of DQOs for bioassessment projects can contact personnel of the Bioassessment and Ecotoxicology Branch in the Ecological Monitoring Research Division, Environmental Monitoring Systems Laboratory-Cincinnati, OH for assistance ((513) 533-8114, FAX (513) 533-8181).

TABLE 1. EXAMPLE OF SUMMARY TABLE FOR DATA QUALITY REQUIREMENTS[1]

Measurement Parameter	Reference	Precision (RPD[2], RSD[3])	Completeness (%)
Benthos	Plafkin et al. (1989)		
No. Individuals		50	95
No. Taxa		15	95
Fish	Karr et al. (1986)		
No. Individuals		25	95
No. Species		15	95
Dissolved Oxygen (mg/L)	ASTM (1992)	5	90
Water Temperature ^{o}C	ASTM (1992)	5	90

[1]From USEPA (1992b).
[2]RPD = Relative percent difference.
[3]RSD = Relative standard deviation.

2.3 Facilities And Equipment

2.3.1 Laboratory, field facilities, and equipment must be in place and operating consistently with their designed purposes so that quality environmental data may be generated and processed in an efficient and cost-effective manner. Suitability of the facilities for the execution of both the technical and QA aspects of the study should be assessed prior to initiation of the study. Adequate environmental controls (space, lighting, temperature, noise levels, and humidity) should be provided. Satisfactory safety and health maintenance features must also be provided (see Section 3, Safety and Health).

2.3.2 Equipment (boats, sampling gear, etc.) and supplies necessary to adequately collect, preserve and process fish and other biological samples must be available and in good operating condition. See Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities, Table 3, General Checklist Of Fish Field Equipment And Supplies.

2.3.3 To ensure data of consistently high quality, a plan of routine inspection and preventive maintenance should be developed for all facilities and equipment. All inspections, calibrations, and maintenance must be documented in individual bound notebooks. This documentation should include detailed descriptions of all calibrations performed, adjustments made, and parts replaced, and each entry should be signed and dated.

2.4 Calibration, Documentation, and Record Keeping

2.4.1 Quality assurance plans should contain mechanisms for demonstrating the reproducibility of each measuring process. Regular calibration of instruments, proper documentation, and permanent record keeping are essential aspects of such plans.

2.4.2 Each measuring device (pH and DO meters, etc.) must be calibrated before each use according to the manufacturer's instructions, and routine checks using National Institute of Standards and Technology standards, or other standards of known accuracy, should be made to demonstrate that variables are within predetermined acceptance limits. Permanent records giving dates and details of these calibrations and checks must be kept. Documentation is necessary to identify each specific measuring device, where and when it is used, what maintenance was performed, and the dates and steps used in instrument calibration. All samples collected and field data sheets should also be assigned a unique identification number and label. Data should be documented to allow complete reconstruction, from initial field record through data storage system retrieval.

2.4.3 Sample tracking is important, but whenever samples are collected to be used as evidence in a court of law, it is imperative that laboratories and field operations follow written chain-of-custody procedures for collecting, transferring, storing, analyzing, and disposing of the samples. The primary objective of chain-of-custody procedures is to create a written record (Figures 1 and 2) can be used to trace the possession of the sample from the moment of collection through the introduction of the analytical data into evidence. Explicit procedures must be followed to maintain the documentation necessary to satisfy legal requirements. All survey participants should receive a copy of the study plan and be knowledgeable of its contents prior to implementing the field work. A presurvey briefing should be held to reappraise all participants of the survey objectives and chain-of-custody procedures. After all chain-of-custody samples are collected, a debriefing should be held in the field to check adherence to chain-of-custody procedures. Chain-of-custody procedures are discussed in four USEPA manuals (USEPA, 1974; 1990b; 1991a; 1992b).

2.4.4 Field and laboratory personnel should keep complete, permanent records of all conditions and activities that apply to each individually numbered sample sufficient to satisfy legal requirements for any potential enforcement or judicial proceedings. The field data sheets and sample tags (see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities; Section 5, Fish Specimen Processing; Section 8, Fish Bioassessment Protocols For Use In Streams and Rivers) should be filled out as completely and as accurately as possible to provide a record in support of the survey and analysis conclusion. Abbreviations commonly used in documentation (e.g., scientific names) should be standardized to decrease data manipulation error. Field and laboratory data sheets and final reports should be filed. All field and laboratory data sheets should be dated and signed by the sampler and analyst, respectively. Notebooks, data sheets, and all other records that may be needed to document the integrity of the data should be permanently filed in a secure fireproof location.

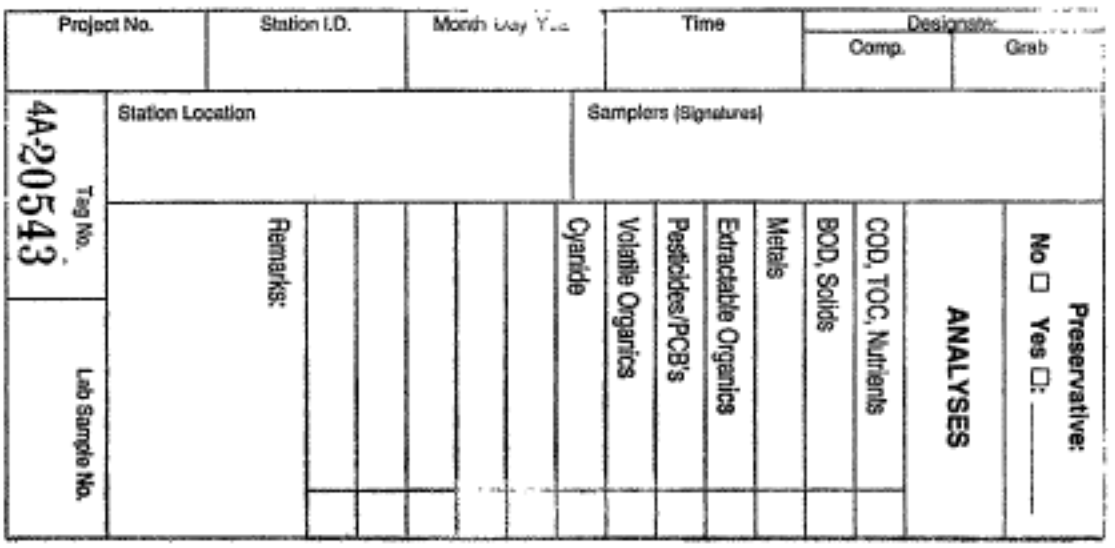

Figure 1. Example of sample identification tag. From USEPA (1990b) and USEPA (1991a).

2.5 Habitat Assessment

2.5.1 Because the habitat characterization procedures (see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities and Section 8, Fish Bioassessment Protocols for Use in Streams and Rivers) are primarily a qualitative evaluation, final conclusions are potentially subject to variability among investigators. This limitation can be minimized however, by ensuring that each investigator is appropriately trained in the habitat evaluation techniques and periodic cross-checks are conducted among investigators to promote consistency. Also, bioassessment laboratories should institute one or two day training courses on habitat characterization and evaluation followed by periodic refresher training. For additional information and discussion on habitat evaluation and a Qualitative Habitat Evaluation Index (QHEI), see Barbour and Stribling (1991), Plafkin et al., (1989), Ohio EPA (1989), Rankin (1989), and USEPA (1990a; 1991b) for additional information and discussion on habitat evaluation and a Qualitative Habitat Evaluation Index (QHEI), regarding rationale, methods, and application for fish bioassessment. Also, see Section 4, Sample Collection for Analysis of the Structure and Function of Fish Communities, Subsection 4.1.5, Habitat Evaluation and Section 8, Fish Bioassessment Protocols For Use In Streams and Rivers, Subsection 8.13.3, Habitat Quality and Assessmemt.

PROJECT NO. | PROJECT LEADER | REMARKS

PROJECT NAME/LOCATION

SAMPLE TYPES
1. SURFACE WATER
2. GROUND WATER
3. POTABLE WATER
4. WASTEWATER
5. LEACHATE
6. SOIL/SEDIMENT
7. SLUDGE
8. WASTE
9. AIR
10. FISH
11. OTHER _____

SAMPLERS (SIGN)

ANALYSES

STATION NO.	SAMPLE TYPE	19__ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	TOTAL CONTAINERS	CIRCLE/ADD parameters desired. List no. of containers submitted	COD, TOC, NUTRIENTS	BOD, SOLIDS	METALS	EXT ORG/PEST/PCBs	VOA	CYANIDE	TAG NO./REMARKS	LAB USE ONLY

RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)	RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)
RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)	RELINQUISHED BY: (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY: (PRINT) / (SIGN)

DISTRIBUTION: White and Pink copies accompany sample shipment to laboratory; Pink copy retained by laboratory; White copy is returned to samplers; Yellow copy retained by samplers.

*U.S. GPO: 1989-732-186

4-20043 (10/89)

Figure 2. Example of a chain-of-custody record form. Modified from USEPA (1990b), USEPA (1991a), and USEPA, Region 4.

2.6 Fish Collection

2.6.1 Ensuring that fish field survey data are representative of the fish assemblage at a particular site requires careful regional analysis and station evaluation. Data comparability is maintained by using similar collection methods and sampling effort in waterbodies (lakes, reservoirs, estuaries, wetlands, streams, rivers, etc.) of similar size . Also, where possible, major habitats in streams (riffle, run, pool) are sampled at each site, and the proportion of each habitat type sampled should be noted.

2.6.2 Precision, accuracy, and completeness should be evaluated in pilot studies along with sampling methods and site size. Variability among replicates from the same site or similar sites should not produce differences exceeding 10 percent at minimally impacted sites and 15 percent at highly impacted sites (Plafkin et al., 1989). Index of Biological Integrity (IBI) differences at the same site should not exceed 4 (Karr et al., 1986).

2.6.3 Data reproducibility may be ensured by having a variety of investigators periodically resample well characterized sites. Investigator precision and accuracy for use of the Index of Biological Integrity (IBI) and the Index of well-being (Iwb) may be determined by having investigators evaluate a standard series of data sets or preserved field collections.

2.6.4 Taxonomists, fishery staff, and aquatic biologists should be capable of identifying fish to the lowest possible level (species, subspecies) and should have at their disposal adequate taxonomic references to perform the level of identification required. See Section 12, Fisheries Bibliography, for a list of selected taxonomic references. Fishery and aquatic biologists should check this list and obtain those references that will be needed for the identification of specimens.

2.6.5 Field identifications are acceptable, but laboratory voucher specimens are always required for new locality records, new species, and any specimens that cannot be identified in the field. All specimens should be retained for laboratory examination if there are any doubts about the correct identification. Biomonitoring laboratories that do not identify fish and other taxa on a regular basis or that have difficulty identifying organisms should have representative specimens of all taxa verified by a specialist who is a recognized authority in that particular taxonomic group. These specimens must be properly labeled as reference or voucher specimens, including the name of the verifying authority, permanently preserved, and stored in the laboratory, or voucher specimens should be offered to regional and state natural history museums for future reference.

2.6.6 Quality control of taxonomic identifications is accomplished by a second qualified individual.

2.7 Qualifications and Training

2.7.1 All personnel need to have adequate education, training, and experience in the areas of their technical expertise, responsibilities, and in quality

assurance (QA). Because no formal academic programs in research QA exist, most QA experience must be acquired through on-the-job training.

2.7.2 At least one professional biologist with training and experience in fish sampling methods and fish identification should be involved directly in the field work or should be involved for at least the first two weeks of the field sampling season (and thereafter if necessary), instructing other less qualified staff in all aspects of the field sampling as well as the laboratory analysis of the samples to ensure data quality. Additionally, the investigators should be familiar with the objectives of each site investigation. Periodic conferences with the sampling crew to assure the sampling effort is being conducted in accordance with the standard operating procedures are also advisable. Statistical expertise should be readily available and consulted during every phase of the project.

2.7.3 Management should periodically assess the training needs of all personnel engaged in QA, and recommend and support their participation in appropriate and relevant seminars, training courses, and professional meetings.

2.7.4 Project personnel should have on file an up-to-date resume for each person who is responsible for the collection, analysis, evaluation and reporting of biological data.

2.8 Standard Operating Procedures (SOPs)

2.8.1 Each laboratory should define the precise methods to be used during each step of the collection, analysis, and data evaluation process. These written procedures become the standard operating procedures (SOPs) describing the operation of the laboratory (USEPA, 1991a). Standard operating procedures for a fish laboratory should describe in stepwise fashion, easily understood by the potential user, at least the following:

1. Sampling methodology, including maintenance of electrofishing gear and seines

2. Replication (duplication)

3. Habitat assessment methodology

4. Sampling site and station selections (including reference sites)

5. Details of preservation and labeling of the samples

6. Use of taxonomic keys

7. Use and calibration of measuring instruments (e.g., DO, pH, and conductivity meters, etc.) and QC requirements

8. Sample chain-of-custody and handling procedures

9. Data analysis, evaluation, and handling

2.8.2 The SOPs must include a listing of the taxonomic keys and references that should be used for each level of identification required and for each taxonomic group. Field experience and taxonomic expertise requirements of personnel for the particular level of bioassessment performed must be defined in the preparation of DQOs. It should also provide an outline of the steps to be taken to assure the quality of the data.

2.8.3 The SOPs must stress the need for the traceability of the fish samples. At a minimum it should specify that the fish sample be assigned a unique identification number and be properly labeled with the sample number, sampling location, date, and name of the collector (see Section 5, Specimen Processing Techniques for an example of sample tags). It should describe procedures to ensure that each sample collected, as accurately and precisely as possible, represents the fish community sampled.

2.8.4 The SOPs should be approved by the proper authority and must be easily accessible to all appropriate personnel for referral.

2.8.5 The laboratory SOPs must be followed as closely as possible. Any deviations should be documented as to the reason for the deviation and any possible effect the deviation might have on the resulting data.

2.8.6 Field validation, conducted at a frequency to be determined by each agency, should involve two procedures: (1) collection of replicate samples at various stations to check on the precision and accuracy of the collection effort, and (2) repeat field collections and analyses performed by separate field crews to provide support for the bioassessment. In addition, field crews should occasionally alternate personnel with the same field training to maintain objectivity in the bioassessment study.

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